M.O. 548 AIR MINISTRY

METEOROLOGICAL OFFICE

THE METEOROLOGICAL MAGAZINE

VOL. 80, No. 950, AUGUST 1951

FREEZING DAYS IN GREAT BRITAIN

By J. E. BELASCO, Ph. D.

This investigation has arisen out of an inquiry from the Study Committee on Basic Design Temperature for Space-Heating Installations.

This Committee was appointed, at the request of the Minister of Works, by the Institution of Mechanical Engineers, the Institution of Electrical Engineers, the Institution of Gas Engineers and the Institution of Heating and Ventilating Engineers to investigate the factors governing the choice of basic design external air temperatures for space-heating installations for domestic and other buildings and the allowance (if any) appropriate to different localities and for various types of building.

In the course of their work the Committee were desirous of learning the incidence, during 25 winters, of days with mean temperature of 32° F. or less (these days are here called freezing days) at the following stations where, it was considered, weather had been experienced which might be regarded as representative for the populous areas of Great Britain: Aberdeen (Observatory), Edinburgh (Royal Observatory), Newcastle (Cockle Park), Manchester (Whitworth Park), Birmingham (Edgbaston), Bristol (Long Ashton) and London (Kew Observatory).

It is thought that the results obtained may be of general interest and they are reproduced here with some additional matter.

Definition of a freezing day.—Two types of these days have been considered according to the method of obtaining the mean daily temperature. A "T-freezing day" is one whose mean temperature is below 32·5° F. and is based on the mean of the sum of 24 hourly temperatures read to tenths of a degree. A "T'-freezing day" is one whose mean temperature is below 32·6° F. and is based on half the sum of the maximum and minimum temperatures read to whole degrees and credited to the day of entry, readings being made at the stations at the hours shown in Table VI.

The average values of $T-T'$ at Kew and Aberdeen for T'-freezing days when they were also T-freezing days have been calculated and are given in Table I.

On the average $T-T'$ is small and positive. Its standard error and range are however large. It appears from the examination of individual values of $T-T'$ that the sign and magnitude of $T-T'$ on any day depend upon n, the number of hours during this day that the lowest hourly temperature was exceeded by more than half the difference between the maximum and minimum

TABLE I—AVERAGE TEMPERATURE DIFFERENCE BETWEEN T- AND T'-FREEZING DAYS

Station	Period	Average $T-T'$	Standard error	Extreme range of $T-T'$	Number of occasions
		degrees Fahrenheit			
Kew	Nov. 1925–Jan. 1950	+0·1	±0·84	−3·0 to 4·5	272
Aberdeen	Dec. 1923–Dec. 1947	+0·3	±0·92	−3·7 to 4·0	211

TABLE II—ANNUAL FREQUENCY OF FREEZING DAYS
Winter beginning in the October of the year shown

***T*-freezing days, Kew**

Year	Frequency	Year	Frequency	Year	Frequency	Year	Frequency	Year	Frequency
	days		days		days		days		days
1878	38	1893	14	1908	15	1923	9	1938	9
1879	34	1894	33	1909	5	1924	2	1939	36
1880	19	1895	4	1910	7	1925	15	1940	13
1881	3	1896	11	1911	7	1926	2	1941	28
1882	11	1897	4	1912	1	1927	11	1942	2
1883	0	1898	9	1913	4	1928	26	1943	0
1884	5	1899	13	1914	0	1929	0	1944	16
1885	32	1900	13	1915	4	1930	10	1945	6
1886	31	1901	19	1916	27	1931	8	1946	42
1887	18	1902	10	1917	12	1932	8	1947	4
1888	20	1903	11	1918	9	1933	12	1948	5
1889	15	1904	11	1919	5	1934	1	1949	4
1890	44	1905	4	1920	6	1935	9		
1891	31	1906	14	1921	7	1936	2		
1892	17	1907	9	1922	1	1937	3		

Total number of T-freezing days = 890

***T′*-freezing days**

Year	Kew	Aberdeen	Edinburgh	Newcastle	Birmingham	Bristol	Manchester
				Frequency			
1927	11	8	10	12	16	12	9
1928	28	20	19	26	30	24	21
1929	0	6	8	10	6	2	4
1930	8	15	8	19	13	9	15
1931	8	2	2	7	9	8	7
1932	10	14	10	13	13	9	9
1933	13	1	1	4	11	12	4
1934	2	1	1	10	5	2	2
1935	14	14	17	27	18	11	18
1936	2	1	13	14	12	1	7
1937	6	5	7	9	6	4	5
1938	10	11	12	13	15	5	8
1939	39	18	33	37	40	36	36
1940	15	19	21	28	24	12	13
1941	30	19	26	36	37	25	33
1942	2	5	6	9	6	2	7
1943	0	4	7	10	9	4	4
1944	19	15	11	17	19	15	17
1945	9	10	13	24	17	15	11
1946	45	29	51	47	53	45	39
Total	271	217	276	372	359	253	269

temperatures of this day. Thus at Aberdeen on January 20, 1936, $T-T'=4\cdot0°$ F. and $n=18$ hr. while on January 22, 1936, $T-T'=-3\cdot7°$ F. and $n=5$ hr.

The magnitude of $T-T'$ is greater at Aberdeen than at Kew. This and the positive sign of $T-T'$ are reflected in the number of T'-days per mille of T-freezing days which at Aberdeen was 1,206 and at Kew 1,126 in the 20 winters, 1927–28 to 1946–47.

Incidence of freezing days.—An examination has been made of T-freezing days at Kew during the 72 winters 1878–79 to 1949–50 and of T'-freezing days at Kew, Aberdeen, Edinburgh, Newcastle, Birmingham, Bristol and Manchester during the 20 winters 1927–28 to 1946–47, winter being defined as the months October to April. The annual variation in the number of freezing days is shown in Table II.

The total number of T'-freezing days in the 20 winters varied from 217 to 372. It would be expected that the variation among the stations of this number would depend upon:

(i) altitude of the station (see Table VI)

(ii) distance inland

(iii) location to east and north of the country (in that cold weather generally comes from the east and north), shelter from east and north, and local topography.

The total number of T'-freezing days at the stations does not suggest that any of these effects predominates. The most marked is that of altitude in that the three stations with an altitude exceeding 300 ft. have a mean number of T'-freezing days of 336 compared with 252 at the four stations below 170 ft.

The annual variation in the number of freezing days was considerable at all stations. The number of T'-freezing days was greatest in the winter 1946–47, that of T-freezing days in the winters 1890–91 and 1946–47. In the seven winters 1909–10 to 1915–16 the total number of T-freezing days at Kew was only about one seventh of that in the seven winters 1884–85 to 1891–92.

From Table II the frequency distribution at each station of the number of winters in ten likely to experience at least a specified number of freezing days has been derived. The results are given in Table III. A chi-squared test has been applied to the frequency distributions at Kew obtained from the T-freezing days in the 72 winters and from the T'-freezing days in the 20 winters. The test shows that the difference between the two distributions is not statistically significant, so that the 20 winters chosen may be considered representative of a long series of winters.

TABLE III—NUMBER OF WINTERS IN 10 WITH AT LEAST A SPECIFIED NUMBER OF FREEZING DAYS

	Type of freezing day	Freezing days 1	5	10	15	20	25	30	35	40	45	50	No. of winters
		Frequency in 10 winters											
Kew	T	9·4	7·2	4·9	2·9	1·8	1·7	1·3	0·6	0·3	0·0	0·0	72
Kew	T'	9·0	7·5	5·5	3·0	2·0	2·0	1·5	1·0	0·5	0·5	0·0	20
Aberdeen	T'	10·0	7·5	5·5	3·5	1·0	0·5	0·0	0·0	0·0	0·0	0·0	20
Edinburgh	T'	10·0	8·5	6·0	3·5	2·0	1·5	1·0	0·5	0·5	0·5	0·5	20
Newcastle	T'	10·0	9·5	8·0	4·5	3·5	3·0	1·5	1·5	0·5	0·5	0·5	20
Birmingham	T'	10·0	10·0	7·0	5·0	2·5	2·0	2·0	1·5	1·0	0·5	0·5	20
Bristol	T'	10·0	7·0	5·0	3·0	2·0	1·5	1·0	1·0	0·5	0·5	0·0	20
Manchester	T'	10·0	8·0	4·5	3·5	2·0	1·5	1·5	1·0	0·0	0·0	0·0	20

TABLE IV—MONTHLY FREQUENCY OF FREEZING DAYS

	Monthly frequency of freezing days											First freezing day in a winter		Last freezing day in a winter	
	Beginning					Ending						Earliest day	Latest day	Earliest day	Latest day
	Oct.	Nov.	Dec.	Jan.	Feb.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.				
Kew, *T*-Freezing days (72 winters*)	0	18	35	13	2	0	2	19	24	22	1	4.11.01	10.2.27	20.12.37	5.4.11
Kew, *T′*-freezing days (20 winters†)	0	2	13	3	0	0	1	3	6	8	0	17.11.30	22.1.33	20.12.37	15.3.47
Aberdeen, *T′*-freezing days (20 winters)	0	3	8	5	4	1	1	4	6	8	0	12.11.44	26.2.34	19.12.37	29.3.41
Edinburgh, *T′*-freezing days (20 winters)	0	2	11	5	2	0	2	2	6	10	0	8.11.27	26.2.34	20.12.37	22.3.37
Newcastle, *T′*-freezing days (20 winters)	0	3	14	3	0	0	1	1	6	12	0	1.11.34	17.1.33	20.12.37	30.3.41
Birmingham, *T′*-freezing days (20 winters)	0	3	15	2	0	0	1	2	6	11	0	17.11.30	18.1.33	27.12.37	16.3.46
Bristol, *T′*-freezing days (20 winters)	0	3	13	2	2	0	3	4	4	9	0	2.11.37	20.2.30	19.12.33, 19.12.37	20.3.30
Manchester, *T′*-freezing days (20 winters)	1	6	10	2	1	0	1	3	7	9	0	26.10.31	14.2.30	20.12.37	20.3.30

* Four winters with no freezing days. † Two winters with no freezing days.

The table shows that there was an even chance each winter of at least 10 freezing days occurring at Kew, Aberdeen, Edinburgh, Bristol and Manchester and of about 15 days at Newcastle and Birmingham.

The frequency at different stations of the different winter months when freezing days began and terminated, and the earliest and latest dates of the first and last freezing days of the winter are given in Table IV.

At all stations freezing days most frequently began in December and ended in March. Over the country as a whole the earliest freezing day may be expected in the last week in October and the last freezing day in the first week in April.

The monthly frequency distribution at Kew of *T*-freezing days within specified limits in 72 winters is given in Table V.

While January had the largest total number of these freezing days, the largest number in any winter was in December and February.

TABLE V—MONTHLY FREQUENCY OF *T*-FREEZING DAYS AT KEW IN 72 WINTERS

	Days												Total No. of freezing days
	0	1, 2	3, 4	5, 6	7, 8	9, 10	11, 12	13, 14	15, 16	17, 18	19, 20	21, 22	
	Frequency												
October	72	0	0	0	0	0	0	0	0	0	0	0	0
November	54	11	5	2	0	0	0	0	0	0	0	0	42
December	25	13	15	8	5	3	0	0	0	0	0	1	231
January	15	19	11	9	6	4	2	4	0	1	1	0	315
February	26	15	15	4	2	4	0	2	0	0	0	1	216
March	50	9	5	5	1	2	0	0	0	0	0	0	85
April	71	1	0	0	0	0	0	0	0	0	0	0	1

Temperature of freezing days.—The average winter (December–February) temperature (calculated as half the sum of the maximum and minimum temperatures) and the average temperatures for the 72 winters of T-freezing days at Kew and for the 20 winters of T'-freezing days at all stations are given in Table VI.

As the Study Committee required the average temperature of freezing days for 25 winters, these have been included in the table together with the lowest recorded temperature of a freezing day. It will be seen that the 25 winters available did not all cover the same years, so that the results obtained from them are not strictly comparable.

TABLE VI—AVERAGE TEMPERATURE OF FREEZING DAYS

Station	Height	Period	Freezing days: Type	No.	Average temperature: Whole period	Average temperature: 20 winters 1927–47	Average temperature: Lowest recorded	Hours used	Average winter temperature
	ft.				°F.	°F.	°F.		°F.
Kew	18	Dec. 1878–Jan. 1950	T	890	29·4	...	17·0	0h.–24h.	40·9
Kew	18	Nov. 1925–Jan. 1950	T'	299	29·7	29·7	19·8	0h.–24h.	40·9
Aberdeen	37	Dec. 1923–Dec. 1947	T'	252	29·8	29·5	21·7	0h.–24h.	39·3
Edinburgh	441	Nov. 1925–Jan. 1950	T'	323	30·1	29·9	21·0	21h.–21h.	40·5
Newcastle	325	Nov. 1925–Dec. 1950	T'	444	29·9	29·8	16·0	21h.–21h.	38·3
Birmingham	535	Nov. 1925–Dec. 1950	T'	413	29·6	29·5	18·0	{day max. night min.}	39·5
Bristol	162	Nov. 1925–Dec. 1950	T'	286	29·3	29·3	18·0	9h.–9h.	41·2
Manchester	125	Nov. 1925–Dec. 1950	T'	307	29·8	29·8	19·0	9h.–9h.	39·4

The variation of the mean temperature of T-and T'-freezing days shows little variation from place to place; the range of T' was only 0·6° F., being about one-fifth that of the average winter temperature. There appears to be no relationship between the average winter temperature and that of T'-freezing days nor between the latter and the altitude of the station.

The monthly frequency distribution of freezing days with mean temperature between specified limits for the 72 winters at Kew is given in Table VII and for the 20 winters at Kew and the other stations in Table VIII.

From these tables the probability of occurrence of mean temperatures less than a specified value can be derived. Thus at Kew the probabilities of days with mean temperature below 23·6° F., 28·6° F. and 32·6° F. were, respectively, once in 3½ winters, about four times each winter and about 14 times each winter.

TABLE VII—MONTHLY FREQUENCY DISTRIBUTION AT KEW OF T-FREEZING DAYS WITH MEAN TEMPERATURE BETWEEN SPECIFIED LIMITS

Period: 72 winters, 1878–79 to 1949–50

	Temperature (°F.): 31·5 to 32·4	30·5 to 31·4	29·5 to 30·4	28·5 to 29·4	27·5 to 28·4	26·5 to 27·4	25·5 to 26·4	24·5 to 25·4	23·5 to 24·4	22·5 to 23·4	21·5 to 22·4	20·5 to 21·4	19·5 to 20·4	18·5 to 19·4	17·5 to 18·4	16·5 to 17·4
	Frequency															
Nov.	7	14	6	8	1	3	2	0	0	1	0	0	0	0	0	0
Dec.	57	43	32	24	22	16	15	6	7	4	2	1	1	0	0	1
Jan.	68	54	56	38	24	25	12	8	12	3	3	6	4	0	1	1
Feb.	63	40	35	22	16	16	8	7	1	1	0	3	1	1	2	0
Mar.	41	17	13	8	3	1	2	0	0	0	0	0	0	0	0	0
Apr.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TABLE VIII—TOTAL FREQUENCY DISTRIBUTION OF T'-FREEZING DAYS WITH MEAN TEMPERATURE BETWEEN SPECIFIED LIMITS

Period: 20 winters, 1927–28 to 1946–47

	Temperature (°F.) 31·6 to 32·5	30·6 to 31·5	29·6 to 30·5	28·6 to 29·5	27·6 to 28·5	26·6 to 27·5	25·6 to 26·5	24·6 to 25·5	23·6 to 24·5	22·6 to 23·5	21·6 to 22·5	20·6 to 21·5	19·6 to 20·5	18·6 to 19·5	17·6 to 18·5	16·6 to 17·5	15·6 to 16·5
	Frequency																
Kew... ...	68	68	37	22	25	20	11	6	8	1	1	3	1	0	0	0	0
Aberdeen ...	62	39	34	26	17	13	7	8	5	4	2	0	0	0	0	0	0
Edinburgh ...	67	56	48	35	20	21	13	8	4	3	0	1	0	0	0	0	0
Newcastle ...	100	78	49	49	33	18	9	12	9	5	5	2	2	0	0	0	1
Birmingham	87	58	48	50	41	22	20	7	9	4	3	4	3	2	1	0	0
Bristol ...	50	48	39	26	29	20	16	4	7	5	2	2	2	2	1	0	0
Manchester...	68	56	41	34	22	16	8	6	6	6	1	3	0	2	0	0	0

Spells of freezing days.—In order that a study can be made of the cumulative effect of low temperature, spells of freezing days have been investigated. The frequency distributions of spells of not less than three consecutive freezing days are given in Table IX. A spell was not considered terminated by one or more days with temperature exceeding 32·4° F. or 32·5° F. provided that the mean of the temperature of the one or more days and that of the preceding day did not exceed 32·4° F. or 32·5° F. according as spells of T- or T'-freezing days are respectively considered. The table also gives the total number of spells and their average duration.

The average duration of a spell exceeded a week at Edinburgh, Newcastle and Birmingham. The longest spell recorded was one of 47 days at both Edinburgh and Newcastle in 1947.

The cumulative effect of these spells on the temperature of the exterior of buildings will depend upon the mean temperature t of each consecutive day of the spell and the length of the spell. The effect is here expressed in terms of the number of "frost-degree days" which have accumulated each day since the commencement of the spell, the contribution of each day to this number being algebraically equal to $(33-t)$ frost degrees, where t is approximated to the nearest whole degree Fahrenheit.

Table X gives the accumulated number of frost-degree days of such spells of seven or more days at Kew in the 72 winters from the first to the last day of each spell. The mean temperature of each spell is included in this table.

It will be seen from this table that the accumulated number of frost-degree days varies among the spells, and in a spell as its duration increases.

Table XI gives, for the 72 winters at Kew, the total monthly number of spells of one or more T-freezing days and the average and maximum monthly

TABLE IX—TOTAL FREQUENCY OF SPELLS OF THREE OR MORE SUCCESSIVE DAYS WHOSE MEAN TEMPERATURE DOES NOT EXCEED THAT OF A FREEZING DAY

	Type of freezing day	No. of winters	Duration (days) of spell 3–5	6–8	9–11	12–14	15–17	18–20	21–23	24–26	27–29	>29	Average duration of spell	Maximum duration of spell
			Frequency										days	days
Kew	T	72	74	24	8	1	4	2	1	1	0	1	6·1	34
Kew	T'	20	20	9	3	1	2	0	0	0	0	1	6·5	32
Aberdeen	T'	20	21	6	2	0	1	0	0	0	1	0	5·6	28
Edinburgh	T'	20	15	10	4	0	1	0	0	0	0	1	7·3	47
Newcastle	T'	20	16	12	8	4	0	0	0	0	0	1	7·9	47
Birmingham	T'	20	18	11	5	3	2	0	0	1	0	1	7·5	45
Bristol	T'	20	17	8	5	1	1	0	1	0	0	0	6·8	32
Manchester	T'	20	18	7	4	0	0	0	0	1	0	1	7·0	33

TABLE X—ACCUMULATED NUMBER OF FROST-DEGREE DAYS IN SPELLS OF SEVEN OR MORE FREEZING DAYS AT KEW

A spell is not considered terminated by one or more days with temperature exceeding 32·4° F. if the mean of the temperature of the one or more days and that of the preceding day does not exceed 32·4°F.

Period: 72 winters, 1878–79 to 1949–50

Date of spell	Day of spell 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	Average daily temperature of spell
	Accumulated number of frost-degree days																																		°F.
9.12.78 –25.12.78	2	7	9	14	20	26	28	30	35	34	33	36	39	42	52	64	69	...	......	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	28·9
5.1.79 –12.1.79	2	7	9	11	13	20	28	33	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	28.9
30.11.79–11.12.79	3	6	15	23	29	34	38	48	47	50	50	58	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	28·2
12.1.81 –26.1.81	4	11	24	39	51	63	72	83	93	103	109	118	126	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	24·6
10.3.86 –17.3.86	1	2	3	4	4	4	6	7	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	32·1
30.12.86–6.1.87	1	7	20	30	27	29	28	29	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	29·4
13.3.87 –19.3.87	2	3	4	5	7	8	10	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	31·6
22.2.88 –1.3.88	2	6	11	14	16	16	17	19	22	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	30·6
13.12.88–6.1.89	5	10	12	15	21	29	34	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	28·1
10.12.90–12.1.91	3	6	11	21	34	40	45	48	52	57	64	63	79	84	88	97	99	100	102	106	114	118	117	123	126	124	125	131	136	140	146	159	171	173	27·9
17.12.91–25.12.91	1	2	6	13	23	34	41	51	56	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	26·8
8.1.92 –16.1.92	2	7	11	11	14	13	14	17	19	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	30·9
7.3.92 –13.3.92	1	4	8	10	11	12	13	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	31·1
24.12.92–7.1.93	3	7	12	21	27	34	41	44	50	59	66	80	92	95	97	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	26·5
26.1.95 –18.2.95	4	10	15	21	26	31	36	38	41	42	50	64	79	92	107	115	121	128	137	145	149	151	158	161	...	...	...	...	...	...	...	...	...	...	26·3
11.12.99–17.12.99	2	1	3	9	15	15	17	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	30·6
7.2.00 –13.2.00	4	9	17	21	21	25	27	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	29·1
10.2.02 –17.2.02	2	4	7	11	14	16	23	26	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	29·7
23.1.17 –9.2.17	1	3	6	10	13	16	20	24	24	25	30	34	37	41	44	52	60	63	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	29·5
11.2.29 –19.2.29	6	16	28	40	52	58	62	68	71	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	25·1
18.12.38–25.12.38	5	12	21	27	28	30	30	31	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	29·1
28.12.39–3.1.40	3	7	11	12	14	17	19	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	30·3
10.1.40 –24.1.40	1	3	3	7	11	15	19	28	34	37	48	56	57	61	65	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	28·7
9.2.40 –18.2.40	1	4	6	12	15	19	21	21	23	25	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	30·5
11.1.42 –22.1.42	5	8	6	8	14	13	16	18	20	27	36	46	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	29·2
16.2.42 –22.2.42	1	3	5	6	10	16	19	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	30·3
20.1.45 –29.1.45	1	3	4	6	12	20	29	36	38	43	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	28·7
23.1.47 –1.2.47	1	4	7	11	15	22	34	41	43	44	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	28·6
5.2.47 –25.2.47	2	6	9	11	12	10	14	20	24	26	28	33	39	44	48	52	57	63	70	78	84	...	...	...	...	...	...	...	...	...	...	...	...	...	29·0
1.3.47 –7.3.47	3	4	6	6	6	8	11	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	31·4

duration of these spells when the mean temperature of a T-freezing day was less than specified values.

Days with mean temperature exceeding 32·4° F. have not been included. When a spell of freezing days was shared between two months unequally, then the spell was assigned to that month which had the greater number of days; when equally, then the spell was allotted to that month which was closer to January than the other month.

While these spells were most frequent in January their average and maximum durations were greatest in February.

TABLE XI—FREQUENCY AT KEW OF SPELLS OF ONE OR MORE CONSECUTIVE T-FREEZING DAYS WITH MEAN TEMPERATURE BELOW SPECIFIED VALUES

Period: 72 winters, 1878–79 to 1949–50

(a) Winter and monthly frequency of spells.
(b) Average winter and monthly duration (days) of these spells.
(c) Maximum winter and monthly duration (days) of these spells.

Mean temperature below		Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Winter
°F.								
	a	23	83	111	68	27	1	313 spells
32·5	b	1·7	2·8	2·8	3·3	3·0	1·0	2·8 days
	c	5	15	12	24	7	1	24 days
	a	11	57	83	45	18	0	214 spells
30·5	b	1·7	2·4	2·2	2·7	1·5	...	2·3 days
	c	4	14	11	11	3	0	14 days
	a	5	34	45	27	4	0	115 spells
28·5	b	1·2	2·2	2·1	2·3	1·7	...	2·1 days
	c	2	6	5	10	3	0	10 days
	a	3	23	26	8	2	0	62 spells
26·5	b	1·0	1·7	1·9	2·7	1·0	...	1·9 days
	c	1	5	5	6	1	0	6 days
	a	1	14	14	3	0	0	32 spells
24·5	b	1·0	1·4	1·9	3·0	...	...	1·8 days
	c	1	2	4	4	0	0	4 days
	a	0	6	8	2	0	0	16 spells
22·5	b	...	1·2	1·6	3·5	...	...	1·7 days
	c	0	2	4	4	0	0	4 days
	a	0	3	4	1	0	0	8 spells
20·5	b	...	1·0	1·3	4·0	...	...	1·5 days
	c	0	1	2	4	0	0	4 days
	a	0	1	2	2	0	0	5 spells
18·5	b	...	1·0	1·0	1·0	...	...	1·0 days
	c	0	1	1	1	0	0	1 day

Table XII gives for the 20 winters the frequency of spells of one or more consecutive T'-freezing days with mean temperature below specified values. Here, days with mean temperature exceeding 32·5° F. have been omitted. The total number of spells, their average duration and the duration and month of occurrence of the longest spell are included in the table.

From this table the average duration of spells of two or more consecutive days can be evaluated. The table shows that the average duration of spells of freezing days below 32·6° F. and 30·6° F. is greatest at Bristol and Newcastle.

TABLE XII—FREQUENCY OF SPELLS OF ONE OR MORE CONSECUTIVE T'-FREEZING DAYS WITH MEAN TEMPERATURE BELOW SPECIFIED VALUES

Period: 20 winters, 1927–28 to 1946–47

Temp. below	Duration of spells (consecutive days) 1	2	3	4	5	6	7	8	9, 10	11, 12	13, 14	15, 16	17, 18	19, 20	>20	Total No. of spells	Average duration of spells	Longest spell: Duration	Longest spell: Month of occurrence
°F.	Frequency																days	days	
KEW																			
32·6	43	17	8	7	3	3	4	2	3	2	0	1	0	0	0	93	2·9	15	Feb.
30·6	33	11	6	3	2	1	0	0	3	1	0	0	0	0	0	60	2·3	11	Feb.
28·6	16	7	4	5	1	2	0	0	0	0	0	0	0	0	0	35	2·3	6	Feb.
26·6	4	4	6	1	0	0	0	0	0	0	0	0	0	0	0	15	2·3	4	Jan., Feb.
24·6	7	3	0	1	0	0	0	0	0	0	0	0	0	0	0	11	1·5	4	Jan.
22·6	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	4	1·5	3	Feb.
20·6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1.0	1	Feb.
ABERDEEN																			
32·6	44	17	10	8	3	1	2	1	1	1	1	0	0	0	0	89	2·4	13	Mar.
30·6	22	14	4	1	2	0	0	1	1	1	0	0	0	0	0	46	2·3	12	Mar.
28·6	17	5	2	1	3	0	0	0	0	0	0	0	0	0	0	28	1·9	5	Jan., Mar.
26·6	11	4	1	0	0	0	0	0	0	0	0	0	0	0	0	16	1·4	3	Mar.
24·6	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	7	1·1	2	Jan.
22·6	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1·0	1	Jan.
EDINBURGH																			
32·6	46	20	6	7	6	3	1	2	1	0	0	1	0	0	1	94	2·9	47	Feb.
30·6	23	10	7	4	3	1	1	0	2	1	1	0	0	0	0	53	2·8	13	Feb.
28·6	17	8	5	4	1	0	0	0	0	0	0	0	0	0	0	35	2·0	5	Jan.
26·6	11	2	3	1	0	0	0	0	0	0	0	0	0	0	0	17	1·6	4	Jan.
24·6	4	0	1	0	0	0	0	0	0	0	0	0	0	0	0	5	1·4	3	Feb.
22·6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1·0	1	Feb.
NEWCASTLE																			
32·6	51	22	12	10	3	8	3	4	2	2	0	0	0	0	1	118	3·1	42	Feb.
30·6	36	14	12	4	5	3	2	1	1	0	0	0	0	0	0	78	2·4	9	Jan.
28·6	26	9	2	3	0	4	0	1	0	0	0	0	0	0	0	45	2·1	8	Jan.
26·6	16	2	3	1	1	1	0	0	0	0	0	0	0	0	0	24	1·8	6	Feb.
24·6	12	1	1	0	0	1	0	0	0	0	0	0	0	0	0	15	1·5	6	Feb.
22·6	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	7	1·1	2	Feb.
20·6	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1·0	1	Jan., Feb.
18·6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1·0	1	Feb.
16·6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1·0	1	Feb.
BIRMINGHAM																			
32·6	65	35	10	6	4	2	3	3	5	2	0	0	0	0	1	136	2·6	22	Feb.
30·6	40	15	6	4	5	2	2	3	2	0	0	1	0	0	0	80	2·4	15	Feb.
28·6	24	6	6	6	1	0	3	0	1	0	0	0	0	0	0	47	2·4	10	Feb.
26·6	13	5	5	1	1	1	0	0	0	0	0	0	0	0	0	26	2·0	6	Feb.
24·6	7	3	1	1	1	0	0	0	0	0	0	0	0	0	0	13	1·9	5	Feb.
22·6	2	2	1	1	0	0	0	0	0	0	0	0	0	0	0	6	2·2	4	Feb.
20·6	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	4	1·5	3	Feb.
18·6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1·0	1	Feb.
BRISTOL																			
32·6	32	8	12	4	2	3	2	2	5	1	0	1	0	0	1	73	3·5	22	Feb.
30·6	19	12	7	7	1	3	0	0	1	0	0	2	0	0	0	52	3·0	16	Feb.
28·6	12	5	6	4	1	2	0	2	0	0	0	0	0	0	0	32	2·8	8	Jan.
26·6	9	3	4	0	1	0	1	0	0	0	0	0	0	0	0	18	2·2	7	Feb.
24·6	5	1	3	1	0	0	0	0	0	0	0	0	0	0	0	10	2·0	4	Feb.
22·6	4	1	1	0	0	0	0	0	0	0	0	0	0	0	0	6	1·5	3	Feb.
20·6	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	3	1·7	3	Feb.
18·6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1·0	1	Feb.
MANCHESTER																			
32·6	46	21	5	6	8	4	2	2	2	0	1	1	0	0	0	98	2·7	15	Feb.
30·6	22	29	4	8	1	1	1	0	2	0	0	0	0	0	0	68	2·1	9	Jan., Feb.
28·6	18	15	1	1	0	1	1	0	0	0	0	0	0	0	0	37	1·8	7	Jan.
26·6	9	3	2	0	2	0	0	0	0	0	0	0	0	0	0	16	1·9	5	Jan., Feb.
24·6	6	3	1	1	0	0	0	0	0	0	0	0	0	0	0	11	1·7	4	Jan.
22·6	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	3	2·0	3	Jan.
20·6	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1·0	1	Jan.

Air masses associated with freezing days.—An examination has been made of the air masses associated with T-freezing days at Kew and Aberdeen during the 20 winters 1927–28 to 1946–47, the total number of freezing days at these stations being respectively 242 and 180. When, as frequently occurred, more than one air mass covered the station during the day (0h.–24h.) that air mass was selected which persisted over the station for the greatest number of hours. The air masses were found to be confined to (*a*) direct polar air moving

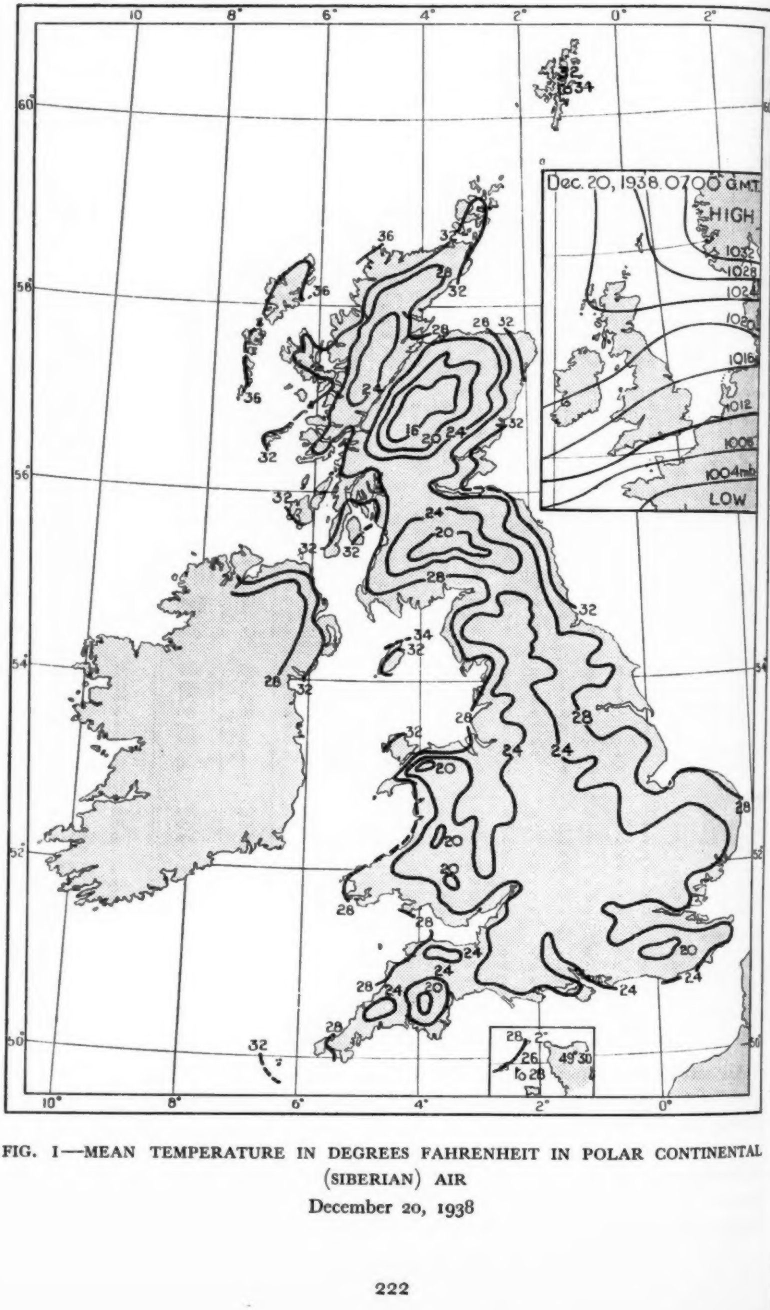


FIG. 1—MEAN TEMPERATURE IN DEGREES FAHRENHEIT IN POLAR CONTINENTAL (SIBERIAN) AIR
December 20, 1938

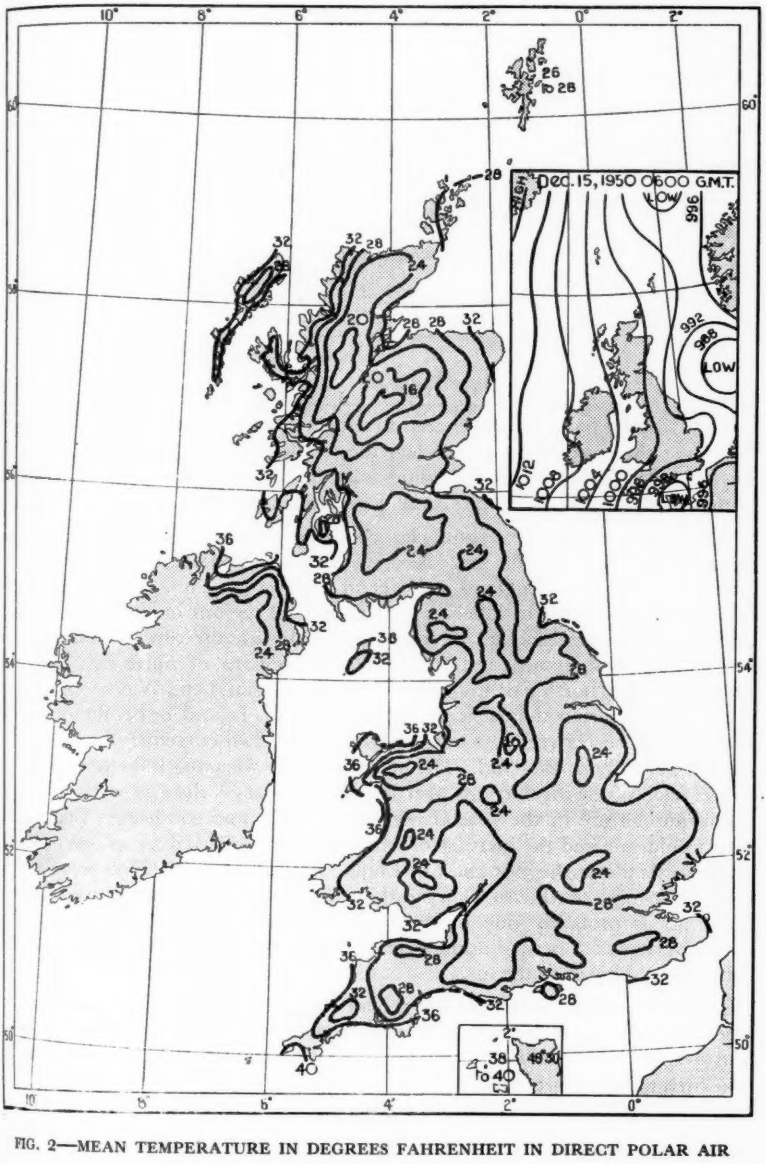


FIG. 2—MEAN TEMPERATURE IN DEGREES FAHRENHEIT IN DIRECT POLAR AIR

December 15, 1950

southwards over the country from beyond latitude 70° N., (*b*) polar continental air, including Siberian air, moving westwards from north-east, east and central Europe, and (*c*) polar air in and near the central regions of moving cold anticyclones.

The percentage frequencies of these air masses on *T*-freezing days at Kew and Aberdeen are given in Table XIII.

The table shows that more than half the number of freezing days occurred in direct polar air at Aberdeen and in polar continental air at Kew.

TABLE XIII—PERCENTAGE FREQUENCY OF DIFFERENT CLASSES OF AIR ASSOCIATED WITH *T*-FREEZING DAYS

Period : 20 winters 1927–28 to 1946–47

	Class of air		
	Direct polar	Polar continental	Anticyclonic
	Percentage frequency		
Kew	14·5	50·4	35·1
Aberdeen	51·6	25·6	22·8

Figs. 1 and 2 have been prepared to show the distribution of mean temperature over the country on days when the whole of Great Britain was covered by (*a*) polar continental (Siberian) air, (*b*) direct polar air. The mean temperature at station level of over 300 stations has been used.

The mean temperature of both classes of air decreases with elevation and with distance inland from the sea. Also, in both air masses mean temperature, except in north-west England, is lower in the east than it is in the west of the country, but whereas in Siberian air the coastal regions of southern England and Wales are much colder than in direct polar air the reverse is the case in Orkneys and Shetlands and in the coastal regions of north-east and east Scotland and of north-east England. Inland in England and Wales temperature is lower in Siberian than it is in direct polar air. Inland in Scotland there is little difference between the temperatures of the two currents. Siberian air is coldest in southern England. The increase in the warming influence of the sea as the fetch of the air currents over the sea increases is shown by the relatively high temperature in the coastal regions of Wales and south-west England in direct polar air and the increase of temperature in Siberian air as one proceeds northwards along the east coast of England. The relatively high temperature over Flintshire, south-east Denbighshire and north-west Shropshire in direct polar air is probably due to the forced ascent of this air associated with condensation and precipitation over the mountains of north Wales and the subsequent descent of the air.

In the mornings the temperatures over East Anglia in Siberian and polar air were respectively 10° F. and 18° F. at 4,000 ft., −7° F. and −3° F. at 10,000 ft. and −25°F. and −22°F. at 15,000 ft. The temperature difference between the two currents therefore decreased with increasing height.

ERRATA

April 1951, PAGE 105, caption to the diagram; *for* " JANUARY 16, 1946 " *read* " JANUARY 12, 1946 ".

May 1951, PAGE 127, key within the diagram; *for* " maximum " read " minimum ", *for* " minimum " *read* " maximum ".

EFFECT OF HEAVY RAIN ON PILOT BALLOONS

Experiments on the effect of rain on the rate of ascent of pilot balloons have recently been made at the meteorological office, Shoeburyness.

The first part of the following report describes the observations made by Messrs. J. Chester, F. A. Landon and L. A. Ibberson during an experiment on May 24, 1951, and the second part by Mr. E. Knighting considers and rejects a suggestion that the balloon was leaking and describes the result of a trial of the release of a wetted balloon from a point 65 ft. up a tower.

Part I—Pilot-balloon ascent in heavy rain

On Thursday, May 24, 1951, very heavy rain followed a thunderstorm which was accompanied by sudden shifts of wind (090°–190°–150°) and a sudden rise in pressure. We decided to make a double-theodolite pilot-balloon ascent in the heavy rain with the object of determining the effect of heavy rain on the rate of ascent of the balloon.

At 0815 G.M.T., when the balloon was launched, there were 5 oktas cumulonimbus, base 1,800 ft., 2 oktas fractostratus, base 800 ft., and 8 oktas nimbostratus, base 6,500 ft.; the surface wind was calm and the visibility in the heavy rain 2,000–3,000 yd. For the first 2 min. of the ascent the rain was heavy; from 2 min. to 4½ min. the rain was very heavy and subsequently the rain became heavy again. In the first 3 min. the balloon rose to about 800 ft., after which it descended and reached the surface of the sea, where it bounced a few times before settling down on the water and drifting out of sight.

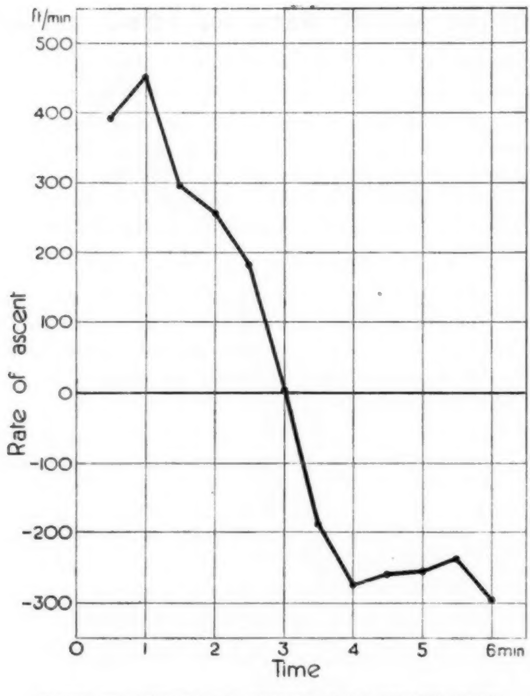
Some extracts from the data are given in the following table:—

DOUBLE-THEODOLITE PILOT-BALLOON ASCENT

Date: May 24, 1951. *Time of start:* 0815 G.M.T.
Length of base line: 530 ft. *Free lift of 48-in. balloon:* 20 gm.
Nominal rate of ascent: 400 ft./min. *Calculated rate of ascent:* 395 ft./min.

Time from start	Wind velocity Direction	Speed	Mean height	Rate of ascent
min.	° true	ft./sec.	ft.	ft./min.
½	102	3	196	392
1	270	1	422	452
1½	247	7	470(570)	96(296)
2	275	15	699	458(258)
2½	270	25	790	182
3	276	19	792	4
3½	276	19	698	−188
4	279	13	561	−274
4½	293	9	431	−260
5	315	8	313	−256
5½	339	6	194	−238
6	015	4	46	−296
6½	350	6	−38	

The readings were difficult to make owing to the heavy rain and we regard the height at 1½ min. as suspect since it is the only reading in which the average height varied by more than about 20 ft. from the individual heights. We have therefore inserted in brackets a reasonable value as given by one of the stations. The resulting rates of ascent are plotted against time in the accompanying diagram.



RATE OF ASCENT OF BALLOON IN HEAVY RAIN

The diagram shows three periods, (*a*) an initial period when there was little or no water on the balloon and the balloon rose at approximately the nominal rate, (*b*) a period in which the rate of ascent declined steadily and water collected on the balloon, (*c*) a period when the rate of descent was steady and no more water was able to collect on the balloon. The second of these periods coincided approximately with the period of very heavy rain. Other factors which may have influenced the downward motion are the downward impact of the rain and possibly a down-draught in the cumulonimbus cloud.

Part II

The balloon referred to in Part I did not behave as leaky balloons do, though as it was lost on the sea certainty is impossible. An inflated balloon which is punctured bursts and the fabric is torn with consequent rapid deflation which certainly did not occur. A balloon punctured before inflation hisses as gas escapes on inflation and cannot usually be blown to full pressure without tearing the fabric. The appearance of the balloon, according to the observers, did not suggest deflation. A 48-in. balloon in equilibrium with its surroundings has a diameter of 32 in. so that a balloon descending for lack of gas presents a surface less than one half of a fully inflated balloon. No diminution in size was apparent but the argument is not strong as it is probably difficult to detect a gradual diminution. It is doubtful if it would have bounced on the sea surface after 3½ min. deflation as an under-inflated 48-in. balloon is flabby.

A trial was made by taking a 48-in. balloon, fully inflated, to near the top of the Conning Tower where it was thoroughly soaked in water and released. On release it fell vertically to the ground and was recaptured. After drying, the free lift was 17 gm. compared with 20 gm. before wetting; it may be that the balloon fabric retains water. The same balloon was re-wetted and released near the ground when it fell and scurried along the ground before slowly rising as the water evaporated and free lift was restored.

This experiment leads to the belief that the descent of the balloon released in heavy rain was produced by deposition of water and not by loss of hydrogen.

ROYAL METEOROLOGICAL SOCIETY

At the meeting of the Society on June 20, 1951, with Sir Robert Watson-Watt, President, in the Chair, Officers for the coming year were formally elected. The new President for 1951–53 will be Sir Charles Normand. The following papers were then read:—

*Smith, E. J.—Observations of rain from non-freezing clouds**

Since the whole of the work covered by this paper had been described by Dr. Bowen to the Society on April 18† at the suggestion of the President the paper was taken as read.

Best, A. C.—The size of cloud droplets ‡

In this paper Mr. Best set out to show why cloud droplets should have diameters within the range 5–40μ. He started from Wright's equation for the vapour pressure over a drop of salt solution leading to a likely maximum value of supersaturation of about 0·05 per cent. He then showed how it was possible to calculate the rate of growth of a drop by condensation, and therefore how large the drop would be before it left the cloud by turbulent diffusion or by falling out under the influence of gravity. The calculated drop radius before being carried out of the cloud by diffusion was in reasonable accord with published measurements of the mean drop radius, and the droplet falling out of the cloud under gravity was of the same order as the largest cloud-drop measurements. At higher temperatures the drop would grow more quickly and would therefore be bigger before it fell out in a shorter time.

Ludlam, F. H.—The production of showers by the coalescence of cloud droplets

Mr. Ludlam gave an entertaining lecture on his paper which was an effort to define the conditions under which showers may develop from convective cloud by the coalescence mechanism. He admitted to making many assumptions but he thought the results were approximately true. Growth by condensation alone was insufficient to produce droplets larger than 110μ in less than a day; a cumulus cloud often only lasted 20 min., and for a shower real drops had to be produced in about 10 min. Since a raindrop was equivalent to as many as a million cloud droplets the coalescence mechanism required relatively few drops to start growing, and it was therefore legitimate to consider only the growth of the largest drops.

Even with giant nuclei a small droplet could only increase by about 2μ in diameter by condensation during 20 min. But evaporation was also slow so

Quart. J.R. met. Soc., London, **77**, 1951, p. 33. ‡*Quart. J.R. met. Soc., London*, **77**, 1951, p. 241.
†*Met. Mag., London*, **80**, 1951, p. 194.

that droplets starting as sea spray would have diameters of 20 or 30μ in a cloud, and he had calculated the growth of such drops.

From Langmuir's formulæ for the efficiency of catch of small droplets it was possible to calculate the rate of growth of the droplets under given conditions of up-draught, initial drop diameter and temperature at the base of the cloud, and therefore the necessary conditions for a shower by the coalescence mechanism. Mr. Ludlam had modified Langmuir's formulæ slightly to allow for the small difference in diameter between the two drops which coalesce. With this modification the efficiency of collection varied between 75 and 100 per cent. when the height above the cloud base exceeded 600 m. Mr. Ludlam showed several diagrams, some illustrating the relation between initial drop size, up-draught and final drop size; some, the decrease in size of drop falling through air of 90 per cent. relative humidity; and some, the variation of minimum cloud depth for shower development as a function of up-draught and initial drop size and also as a function of temperature at the cloud base. The minimum condition for showers is given as the production of drops exceeding 150μ in radius, and the consequent variation of cloud depth is from 1,400 m. at cloud-base temperature of 20°C. to 1,800 m. at cloud-base temperature of $-5°$ C.

As a further corollary to his theory Mr. Ludlam also suggested that raindrop breaking could only occur with cloud depth greater than certain given heights and only if the raindrop did not pass through the ice phase. In support of this statement he showed a map of " sferic " activity over the northern North Atlantic during November and December 1949. The activity, except for a distant area of low accuracy of observation, was confined to the south of the 43° F. sea-temperature isotherm which corresponds to a cloud-base temperature at 2,000 ft. of 0° C.

In the discussion on these three papers Mr. Mason thought Mr. Best had assumed his answer to start with in the calculation of the excess vapour pressure. Mr. Gold questioned the application by Mr. Best of O. G. Sutton's dispersion formula to the turbulent transfer of a droplet out of the cloud since turbulence depends on wind shear not wind speed. He thought Mr. Ludlam should have considered the cloud-droplet size more carefully, for there was a tendency for drops to be of uniform size which would produce a separation of the different sizes into layers. Mr. Woodcock queried Mr. Ludlam's modification of Langmuir's collection coefficient from approximately $\frac{1}{4}$ to nearly $\frac{3}{4}$ or 1.

*Scorer, R. S.—Billow clouds**

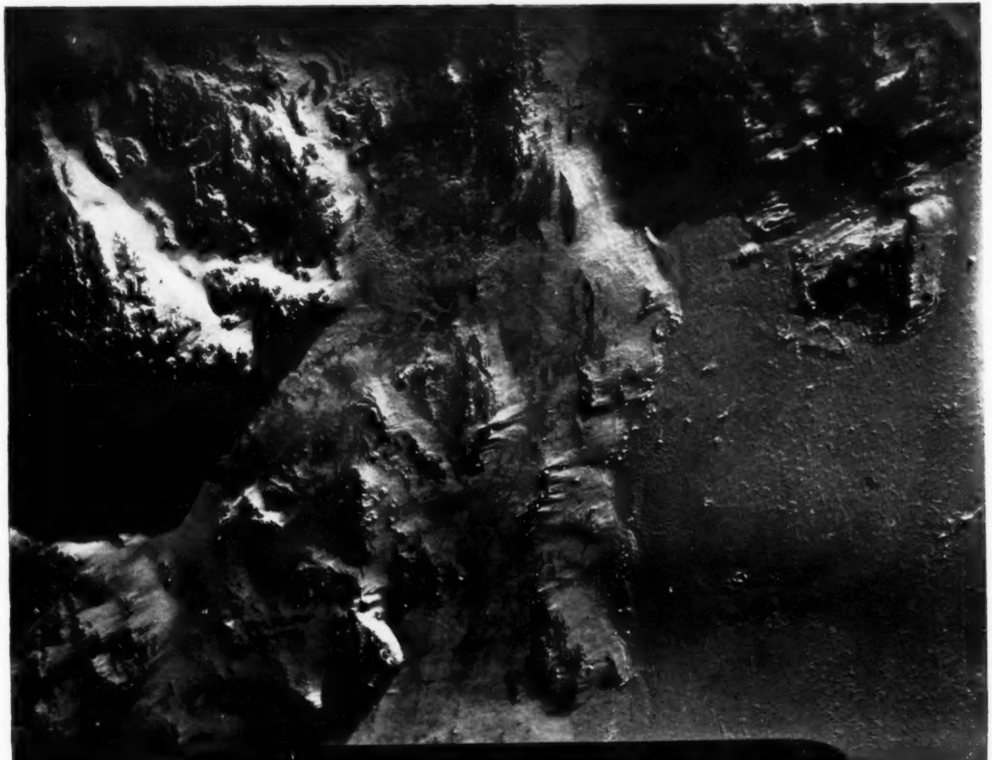
Dr. Scorer pointed out some difficulties in the generally accepted theory of the formation of billow clouds as convection cells whose configuration is influenced by shearing motion at the almost horizontal boundary between two air currents. Although laboratory experiments had reproduced many of the patterns, conditions had to be exactly right. This fitted in with Jeffreys' further assumption that the motion will only just take place in order to obtain the cell size. The conditions are not usually exactly right in the atmosphere; and furthermore a convection cell is a mechanism for the continuous transport of heat—which was not likely to take place at a transition boundary.

Quart. J.R. met. Soc., London,* **77, 1951, p. 235.

Photograph by R.A.F.

FIG. 1—ONUNDARFJORDUR NEAR BOLUNGARVIK, NORTH-WEST ICELAND

(see p. 233)

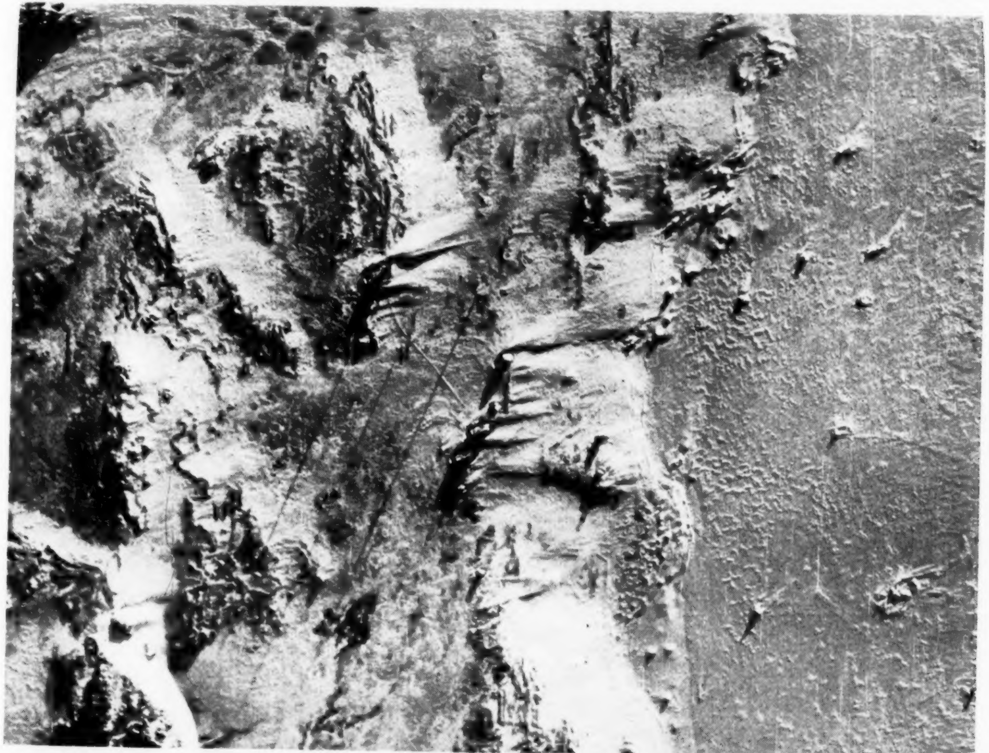


Photograph by R.A.F.

FIG. 2—AREA AROUND DANMARKSHAVN, NORTH-EAST GREENLAND

Photograph by R.A.F.

FIG. 2—AREA AROUND DANMARKSHAVN, NORTH-EAST GREENLAND



Photograph by R.A.F.

FIG. 3—SYNOPTIC REPORTING STATION DANMARKSHAVN

To face p. 229]

Photograph by R.A.F.

FIG. 4—TRAPPER'S ENCAMPMENT AT HUALROSODDEN NEAR DANMARKSHAVN

The theory suggested by Helmholtz of waves at a surface of discontinuity did not explain the appearance of a single wave-length, and although Wegener had obtained a single wave-length this was by arbitrarily assuming that the waves travelled with a velocity equal to the mean of those above and below the discontinuity. Alternatively one could assume that there was a layer of unstable air, but then vertical overturning occurs and the problem is again one of convection.

Dr. Scorer therefore produced the theory that there was a row of parallel vortices at the level where stable waves existed between the wind currents. This led to a formula, wave-length $=2{\cdot}6938h$, where h is the depth of the statically unstable layer. He showed photographs, from the Clarke Collection, illustrating billow clouds which he thought had been derived according to his theory.

In the short discussion which followed Dr. Sutcliffe wished more distinction had been made between cloudlets that were distinct in themselves and cloud forms such as lenticular clouds which remained more or less stationary with cloudlets passing through them. Mr. Ludlam drew attention to the well known danger of taking nephoscope observations on wave clouds.

LETTERS TO THE EDITOR

High-level cloud photographs

We should like to make a few comments on the notes given by G. W. Hurst on his Figs. 4 and 5 in the March 1951 issue of the *Meteorological Magazine*.

The " fault " shown in Fig. 4 is quite different from the one described by Frith in *Nature**. The latter was straight and the cloud top on each side was at the same level. It appeared that the " fault " might have been a V-shaped trough in the cloud top. In the former, on the other hand, the height of the cloud top is clearly different on each side of the "fault".

Investigations of the temperature structure of cloudless inversions carried out by the Meteorological Research Flight using a thermometer with a very rapid response have shown that the increase in temperature with height is often confined to a layer less than 100 ft. thick, and that the height of this layer appears on occasions to change abruptly. It is possible that Mr. Hurst's Fig. 4 shows a cloud structure associated with such a discontinuity.

Mr. Hurst explains the bright spot in Fig. 5 as reflection of the sun from a lake or river surface. It seems to us, however, that it is a good example of a sun image produced by reflection of the sun from the flat surfaces of ice crystals. Although it does not appear to be in the cloud, there are always many ice crystals around and below the type of cloud shown in Fig. 5 which would produce the image. These might not show up clearly on a photograph, and, in fact, might not even be visible from the aircraft. A sun image apparently clear of cloud is a very common feature and its presence is often the only evidence for the existence of ice crystals.

D. R. GRANT
RONALD FRITH
H. C. SHELLARD

June 6, 1951

*FRITH, R.; Details of wind structure revealed by artificial nucleation of supercooled clouds. *Nature, London*, **165**, 1950, p. 899.

Precautions to prevent sea-gulls stealing sunshine cards

I have had considerable previous trouble with sea-gulls attacking the sunshine recorder, notably during the winter of 1949–50 during reconstruction of its usual site when I used a neighbouring roof.

I found cutting off the ends of the cards fairly effective but it makes them very difficult to get out. The recorder used to have clamping screws but they have corroded away. A pin through the hole serves quite well.

But I have recently been trying another idea. I argued that the birds stand near the recorder while pulling at the card. I have tried to make this impossible to a web-footed bird by using old pieces of board with $1\frac{1}{2}$ in. panel pins scattered over them points upwards (driven through from the back), so far with success. Rather dangerous to the one in charge of the instrument, too, so I have found!

C. WINDASS

Observatory Office, Torquay, June 27, 1951

NOTES AND NEWS

Napier Shaw Library, Cambridge

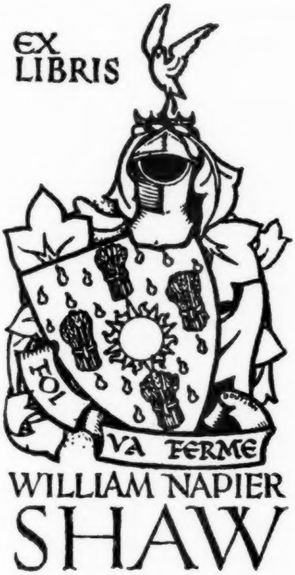
Sir Napier Shaw possessed what was probably the largest private library of meteorological books in the country, and in his will he expressed the wish that "a permanent home within the precincts of the University of Cambridge" be found for it with a view to promoting the future study of the atmosphere. Until recently these books have been in the charge of the Director of the Observatory at Cambridge, but the recent decision to centralize meteorological activity in the Cavendish Laboratory has resulted in the transfer of Shaw's Library as well.

During the afternoon of June 11, 1951, the formal opening of the Napier Shaw Library, which is now housed in one of the rooms of the Cavendish Laboratory, was performed by the Vice-Chancellor of the University, who was supported by the Cavendish Professor and the Mayor of Cambridge. Some 25 distinguished meteorologists from many parts of the country were present. In a brief but felicitous speech the Vice-Chancellor recalled the association of Sir Napier Shaw with the Cavendish Laboratory, and declared the Library open. Speaking on behalf of Sir Napier Shaw's Trustees, Miss Austin expressed appreciation of the steps the University has taken to carry out the wishes of Sir Napier Shaw.

Every meteorologist will wish to echo the sentiments expressed by Miss Austin, and will be glad to know that the great debt we all owe to Sir Napier for his outstanding contribution to the science of meteorology is enhanced by his foresight in thus making his library available to later generations of research workers.

In addition to the books, certain other interesting relics were bequeathed to the University, including a clock, Shaw's Royal Medal, his Symons Memorial Medal, his Buys Ballot Medal, and an imposing document in which the College of Arms granted to Sir Napier Shaw his coat of arms. The clock was one given to Shaw by his colleagues in the Cavendish Laboratory and which thus returns to its place of birth.

Shaw's coat of arms will be of interest to those who are concerned with the help that meteorology can give to agriculture. It consists, in ordinary parlance, of a sky-blue shield on which a radiant sun is placed centrally and surrounded by heraldic raindrops and four sheaves of corn. The crest above the coat of arms depicts a " stormy petrel " in flight over a rough sea. The coat of arms was used by Shaw as a book-plate, and is thus shown below, together with its description in heraldic terminology.



SIR NAPIER SHAW'S COAT OF ARMS
USED AS A BOOK-PLATE

Azure guttes d'eau a Sun in splendour Argent between four Garbs in cross Or and for the Crest On a Wreath of the Colours: On waves of the sea a Petrel passant and volant all proper.

Temporary formation of a surface inversion as a consequence of wintry showers

A remarkable example of the cooling of the surface temperature by a wintry shower was seen on the Cumberland coast on February 6, 1951. This cooling led to the formation of an inversion, from the surface to a height above 350 ft., which persisted for $2\frac{1}{2}$–3 hr. The presence of this inversion was made plainly visible by a smoke trail from a factory chimney. It was the unexpected behaviour of this smoke trail that led to a closer examination of the meteorological records. The detailed sequence of weather was as follows:—

A slight shower of rain commenced at 0830 G.M.T., and became a heavy hail shower at 0853 with 8 oktas cumulonimbus, base estimated at 800 ft., and 2 oktas fractocumulus at 600 ft. The shower turned to moderate snow for a short time at 0903 before its cessation. The visibility during the hail shower

was 2½ miles. At 0930 another hail shower occurred, and though it was not nearly so intense as the previous one, the visibility fell rapidly to 900 yd. and the cloud base fell to the surface. By 0955 the visibility had improved to 1½ miles and the cloud base to 700 ft., and it was then that the peculiar behaviour of the smoke trail became apparent. A further hail shower occurred at 1045 and a snow shower at 1120, the latter being accompanied by a squall to 33 m.p.h.

The temperatures recorded in the screen during this period were:

	0900	1000	1030	1100	1200
			degrees Fahrenheit		
Dry bulb	37·0	33·2	33·2	33·3	36·2
Wet bulb	35·0	32·8	...	33·0	35·8

The interesting feature about these temperatures is the fall between 0900 and 1000 to a point below the previous wet-bulb temperature. A fall to this latter value would represent the maximum cooling possible as a result of the evaporation of falling rain. The additional cooling below the previous wet-bulb temperature, leading to the fog (cloud) formation, was presumably a result of the precipitation reaching the ground as ice, and probably existed in only quite a shallow layer (see Fig. 1).

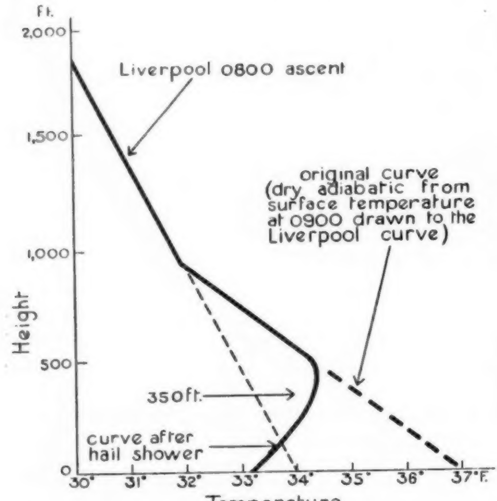


FIG. 1—PROBABLE TEMPERATURE VARIATION WITH HEIGHT BEFORE AND AFTER THE HAIL SHOWER

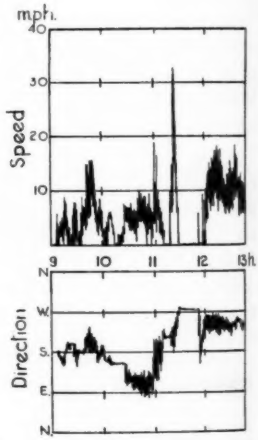


FIG. 2—ANEMOGRAPH TRACE

The anemograph trace for the period (Fig. 2) shows two interesting and contrasting features. These are (i) the almost complete lack of turbulence, shown by the very narrow direction trace between 1005 and 1020, and (ii) the well defined squall from calm to 33 m.p.h. and back to calm at 1122 indicative of the real instability of the air mass, as were also a squall to 20 m.p.h. at 0849 and the subsequent showers.

Fig. 3 is a diagrammatic representation of the smoke trail. This issued from a stack 60 ft. high and formed, for a time, a quite dense and almost stationary cloud over a building 200 ft. high, and some 150 yd. away. The top of another stack 400 ft. above ground, and rising out of the building was plainly visible above the smoke cloud which levelled off at a height of 350 ft. and then descended out of view behind some buildings, but apparently almost to ground level, a short distance further on.

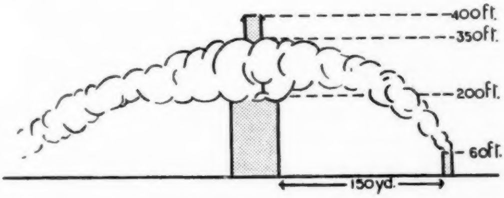


FIG. 3—DIAGRAMMATIC REPRESENTATION OF SMOKE TRAIL

The Liverpool ascent at 0800 showed a lapse of temperature from 34° F. at surface to 32° F. at approximately 1,400 ft., above which the air mass was quite unstable to about 20,000 ft. No 0800 local surface temperature was available, but at 0900 it was 37·0° F., and the minimum temperature for the 24 hours ending at 0900 was 36·7° F.

The appearance of the smoke trail leads to the assumption that an inversion had formed with top above 350 ft. Having regard to the available temperature information and the weather phenomena it is probable that this inversion was very steep near the surface, and Fig. 1 depicts the probable change in temperature with height before and after the first hail shower. The inversion persisted till about 1145 as could be seen by the smoke trail keeping an almost level path at about 350 ft. but in various directions as the wind shifted. The shape of the smoke trail can be explained on the supposition that the smoke was warmer than the surrounding air at the top of the chimney, and that its initial uplift was sufficient to carry it up through the inversion to 350 ft. and no further, as it descended again from that level. Further supporting evidence of the existence of the inversion is shown on the anemograph trace by the effect on the surface wind when it broke down just before 1200.

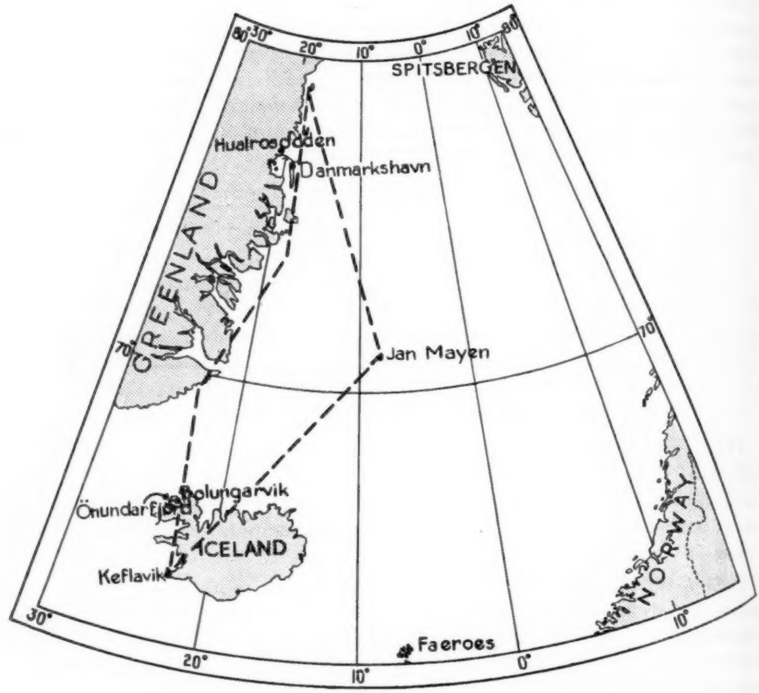
At 0600 the synoptic chart showed a deep but slowly filling depression off north-west Scotland, with unstable air on its western and southern sides. The gradient wind over the Cumberland coast was 230° 30 m.p.h.

B. H. IMRIE

May 16, 1951

Arctic flight by aircraft of R.A.F. Station, Shawbury

Special navigation exercises were carried out by members of No. Nine Specialist Navigation Course, Shawbury on March 13 and 15, 1951. The four Lancaster aircraft used for the flights were based at Keflavik, Iceland, having left Shawbury on March 9 and 11. The routes flown were the same on both days: Keflavik–Jan Mayen–79° 05′ N., 18° 00′ W.–74° N., 18° W.–69° 30′ N., 23° 30′ W.–Keflavik, being of 11 hours' duration. Time of take-off was 0430–0500 G.M.T.



ROUTES OF THE SPECIAL NAVIGATION EXERCISES

From a weather point of view there were a number of interesting features on both flights. The " weather barrier " coincided with the sea-ice barrier on both days. This extended in a north-east–south-west direction at 74° 30′ N. on the track north of Jan Mayen and was recrossed at 69° 10′ N. on the track from Greenland to Iceland. On both days cloud broke completely over the ice although there was appreciable cloud over the sea and pack ice.

Flight of March 13.—There was much cumulus to 14,000 ft. over the open sea, but turbulence and icing were only slight on the northward legs. On the return to Iceland, however, severe turbulence and moderate icing were experienced in cumulus cloud which extended only to 8,000 ft.

On descent over the ice cap there was a 5° C. fall in temperature in the lowest 1,000 ft.

Visibility was extremely good except near the northern turning point and down the east coast of Greenland. Here all reports indicated the presence of " ice-crystal " haze which reduced visibility to very low limits. The haze extended from the surface to above 8,000 ft., almost obscuring the sun at times. The phenomenon extended to 72° N., at which point visibility improved rapidly.

Flight of March 15.—Cloud was much more shallow than on the previous flight, but an active front appears to have been crossed at 68° N. and recrossed

on the southern route at 70° 15′ N. On this occasion visibility over the ice was excellent.

Temperatures at 8,000 ft. varied from −18° C. to −22° C. and a temperature of −46° C. was recorded at 20,000 ft. on crossing the front northwards. There were signs of marked katabatic effects on the east Greenland coast where local westerly surface winds appeared to undercut the prevailing easterly drift in places.

Fig. 1 (facing p. 228) shows a typical stretch of north Iceland, the Onundarfjórdur near the synoptic reporting station, Bolungarvik (66° 10′ N., 23° 15′ W.). Fig. 2 shows the area around the synoptic reporting station, Danmarkshavn (76° 46′ N., 18° 46′ W.), while Fig. 3 shows the station itself. It will be noted that the sea is completely frozen. Wind drifts of the snow can also be clearly seen indicating the prevailing wind direction. Shadows cast by the three radio masts stand out clearly. Fig. 4 shows a trapper's encampment at Hualrosodden (76° 56′ N., 20° 15′ W.) near to the station at Danmarkshavn. Musk ox were seen in the vicinity.

Grateful acknowledgement is made to Group Captain B. J. Roberts, Commandant, Shawbury, for permission to publish photographs taken during the flights.

A. BEYNON

Expedition to northern Norway

An interesting report on the meteorological observations made by the British Schools Exploring Society's expedition to northern Norway in August and September 1950 has been received from Mr. F. G. Hannell, of the Geography Department of Bristol University. Some notes on the more remarkable features of the report are given below.

The expedition visited the Kildetoppen Massif where the main observing station was installed on a moraine at 67° 45′ N., 16° 05′ E., at a height of 1,650 ft. above M.S.L. Eight subsidiary stations were installed at points at heights from 585 to 3,100 ft. above M.S.L. and arrangements made for twice-daily readings to be taken at all of them nearly simultaneously. Stevenson screens could not be taken because of the weight, and the thermometers were exposed in wooden boxes with holes bored in them above bulb level.

Remarkably high temperatures occurred between August 16 and 20 in a SE. air stream which had come from central Europe. The maximum temperature at the 588-ft. station on the 19th was 84° F. and at the 1,650-ft. station 78° F. The temperatures do not seem to have been seriously raised by the unorthodox exposure as the Swedish daily weather report gives high maxima in northern Sweden at this time, and on the west side of the mountain chain some föhn heating probably raised temperature further. During the period August 20–29 the station was under the influence of an anticyclone and marked inversion was noted. The minimum temperature during the day on August 23 was 4° F. lower at the 585-ft. station than at the 1,650-ft. one, and the minimum for the night August 22–23 was 19° F. lower. The mean night minimum for the period August 21–27 was 11° F. lower at the low-level station. Frost occurred at the 1,650-ft. station on four nights out of the 22 days on which the expedition took readings and the lowest minimum was 29° F. on the night September 1–2.

The main station measured only 1·09 in. rainfall in the 22 days, though the normal rainfall for August is between 2 and 3 in. in this area. Southern Norway and the British Isles experienced a very wet August.

Five auroral displays were seen, and two of them, on September 3 and 4 were entirely to the south of the zenith.

The Society is visiting central Iceland in the summer of 1951 and taking more extensive meteorological equipment lent by the Meteorological Office.

Random errors in standard observations

During 1949, at Kew Observatory, four sets of instruments, comprising wet, dry, maximum and minimum air thermometers in Stevenson screens, 4-in. and 8-in. soil and 1-ft. earth thermometers, and grass minimum thermometer, were maintained over a level grass site with apparently identical standard exposures. Readings of all thermometers were taken twice daily.

For the purpose of analysis the "correct" readings were taken to be the means of the four individual readings. The divergencies of the individual readings from the mean were then examined giving the following percentages within the 2σ range:—

Element	Time of observation	Proportion within 2σ range	2σ range
	G.M.T.	%	
Dry bulb	0930 and 1500	97·3	±0·4°F.
Minimum	0930	95·4	±0·3°F.
Maximum	1500	95·4	±0·5°F.
Grass minimum	0930	95·7	±1·6°F.
Relative humidity	0930 and 1500	96·8	±2 per cent.
Dew point	0930 and 1500	95·9	±0·9°F.
4-in. soil	0930	95·3	±0·4°F.
8-in. soil	0930	96·2	±0·4°F.
1-ft. earth	0930	95·7	±0·4°F.

The variance of the-dry bulb, soil and earth temperatures increased with increase of temperature. That of the extreme readings and the relative humidity showed little change, but the variance of the dew point decreased with increase of dew-point temperature.

In synoptic reports, temperatures are reported to the nearest whole degree. The possible frequency of divergence from the correct reading is as follows:—

	Reading low by			Correct	Reading high by			
	3°F.	2°F.	1°F.		1°F.	2°F.	3°F.	4°F.
				percentage frequency				
Dry Bulb <60°F.	...	...	5·6	89·1	5·3	...	...	...
Dry bulb >60°F.	...	...	7·3	85·5	7·2	...	...	...
Minimum at 0930	...	...	5·1	89·4	5·5	...	...	...
Maximum at 1500	...	...	9·0	82·8	8·0	0·2	...	...
Grass minimum at 0930	0·1	2·8	24·5	51·3	17·0	2·8	1·3	0·2
Dew point at 0930 and 1500	...	0·6	14·6	71·1	13·1	0·6	...	...

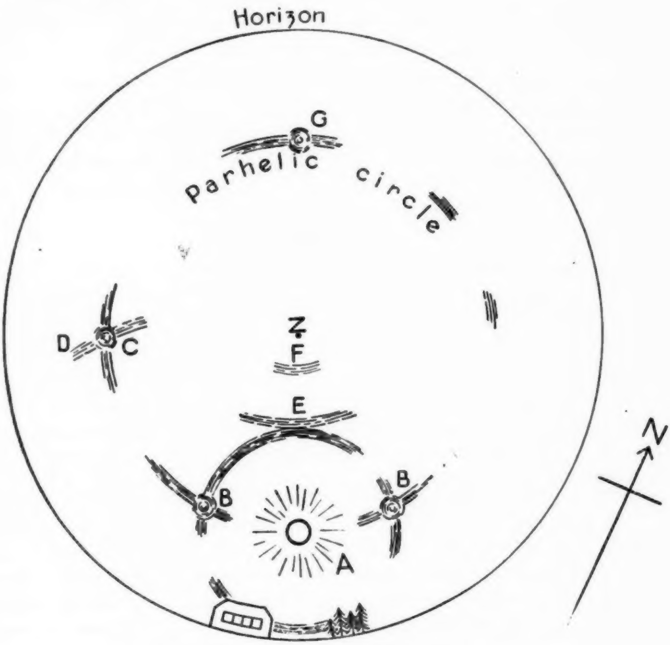
We may thus conclude that in synoptic reports a tolerance of plus or minus 1° F. may be admitted in dry-bulb, maximum and minimum temperatures, and dew points, and plus or minus 2° F. in grass minima.

A full report of the investigation will be published elsewhere.

L. P. SMITH

Halo phenomena at Gatow

Between 0950 and 1010 G.M.T. on Monday, February 19, 1951, a very unusual halo complex was observed from the meteorological office at Gatow near Berlin. This comprised a well defined, but broken, parhelic circle together with the two 22° mock suns, the 90° mock sun and a portion of the extremely rare 90° halo to the west and also the counter sun or anthelion. An almost complete 22° halo with upper arc of contact and the circumzenithal arc were also clearly visible. The upper arc of contact of the 22° halo was highly coloured but the circumzenithal arc was not coloured. The circumzenithal arc is usually brightly coloured.



HALO PHENOMENA AT GATOW, FEBRUARY 19, 1951

A Sun.
B Mock suns of 22° halo.
C 90° mock sun.
D Possibly a small vertical arc of the 90° halo.
E Arc of contact of 22° halo.
F Circumzenithal arc.
G Counter-sun or anthelion.
Z Zenith.

The parhelic circle was particularly bright at the 90° mock sun.

This complex was also observed from the Potsdam Observatory where the easterly 90° mock sun was also seen.

Weather at the time was fair with 4 oktas cirrus and cirrostratus, well scattered, with some altocumulus and altostratus and some high stratocumulus at about 5,000 ft., making a total of 7 oktas and giving the sky a chaotic appearance.

A trough of low pressure along longitude approximately 4° E. was moving eastwards and reached the Berlin area at about 2100 G.M.T. with a period of slight rain.

Bulletin du Service Météorologique du Congo Belge

We welcome publication of the first number (January 1951) of the *Bulletin du Service Météorologique du Congo Belge.*

The first part of the bulletin consists of three articles: a comparison between the Campbell-Stokes and Marvin sunshine recorders by Dr. W. Schuepp leading to the conclusion that the former is the more effective in the tropics, a report on the distribution of thunderstorms over the Belgian Congo in 1945 by Dr. P. Goedert, and a note by M. G. Heinrichs on the terrestrial magnetic observations made at Elisabethville between 1938 and 1950.

The second part of the *Bulletin* consists of a report on the weather of January 1951 in the Belgian Congo and the district of Ruanda-Urundi. In this part daily maximum and minimum temperatures, rainfall and sunshine are given in diagrams. Monthly wind roses for the surface and for varying heights in the atmosphere to 7,800 m. for Costermansville are also provided.

REVIEWS

Report on the snow survey of Great Britain for the season 1949–50. By E. L. Hawke and D. L. Champion. *J. Glaciol., London.* **1**, 1951, pp. 516–26, *Illus.*, British Glaciological Society, London. Offprint. Price: 2*s.* 6*d.*

The annual report of the Snow Survey of Great Britain for the period September 1949 to September 1950, published in the *Journal of Glaciology* contains besides the usual month by month description of snowfall and notes on the duration of mountain snow cover an interesting new section on snowfall in British coastal waters based on observations taken on lightships.

The highlight of the year was the heavy snowfall of April 26, 1950, south of the Thames.

No snow at all fell on the "Seven Stones" lightship off Cornwall or, more surprisingly, on the "Helwick" and "English and Welsh Grounds" lightships in the Bristol Channel. The latter ship is only some 5 miles from land about midway between Cardiff and the Somerset coast.

We extend our congratulations to Messrs. Hawke and Champion on this valuable report.

G. A. BULL

Weather and the building industry. A Research Correlation Conference on climatological research and its impact on building design, construction, materials and equipment held at the National Academy of Sciences. *Res. Conf. Rep., Washington D.C.*, No. 1, 1950, 10¾ in. × 8¼ in., pp. viii + 159, *Illus.* Building Research Advisory Board, National Research Council, Washington D.C. Price: $3.50.

The importance assigned to weather and climate in the design and construction of houses in America is shown by their being made the subject of the first of a series of conferences arranged by the Building Research Advisory Board of the United States, which was attended not only by builders, architects and

engineers, but also by such well known meteorologists as Dr. Reichelderfer and Dr. Landsberg. The Conference produced a good deal of useful and interesting information, but even more food for thought, on both sides of the fence. The meteorologists said with one voice: "Tell us what you want, and we will provide it." The architects replied with almost equal unanimity: "Yes, but provide it in a form that we can use." The Report of the Conference is published partly with the aid of a grant from the far-seeing management of the magazine *House Beautiful*, and it is worthy of remark that the most helpful effort at bridging the gap between climate and the home originated from research undertaken by this magazine. This was a paper by Dr. Paul Siple, "Climatic criteria for building construction", which sets out a striking series of monthly diagrams of frequencies and extremes—air temperature and dew point, sunshine, wind, precipitation, relative humidity and vapour pressure. It also included such necessary data, to the wise planner, as elevation and azimuth of the sun. A notable (and noticed) omission was snowfall. The specimen published is for Phoenix, Arizona, but similar diagrams have been prepared for a number of other cities, and all are being published in the *Bulletin of the American Institute of Architecture*, with text explaining their impact on architecture and construction.

It came out repeatedly in the Conference that extremes and frequencies are both needed, but not averages. "Nature does not produce averages, the statistician does that." Extremes are wanted so that the architect shall know what his building may have to stand up to, but even so, there was diversity of opinion (from 100 years downwards) as to how long it had to stand up for. Frequencies are needed so that the house may be most comfortable for the greatest possible part of the time. Comfort, in this context, is defined as not noticing the environment. It depends to some extent on clothing, and one speaker remarked that as fashion decrees more and more scanty clothing, so the "comfortable" temperature rises. Moreover, it is very doubtful how far statistics, even frequencies of single elements, are safe guides. Statistics of wind lose much of their value unless we know the temperature distribution with each speed from each direction, and how often it is accompanied by sunshine, rain and snow. Such combined statistics are very costly to obtain by hand tabulation; in fact they are only possible to any appreciable extent by machine analysis of punched cards. Delegates heard a great deal about the eighty million cards collected by the Weather Bureau, but even these only permit analysis of five years' data. Little was heard about the more scientific approach by the study of frequency distributions of correlated series, but this may actually turn out to be the answer.

The difficulty does not end with the production of suitably digested figures for conventionally exposed climatological stations. Dr. Landsberg ("Microclimatic research in relation to building construction") rammed home the fact, still too little realized, that there may be a whole range of climates within the confines of a single city, and the differences may be equivalent to changes of location by hundreds of miles. Moreover, he and several other speakers showed how, by the suitable placing of grass and cement, windows, walls and trees, the microclimate of a house can be modified both outside and in. The thermal capacity and heat transmission of the walls are especially important, for analysis showed that in winter a house loses four fifths of its heat through the walls and only one fifth by ventilation.

The cheapest way of providing homes is by mass-produced buildings from standard parts and materials, but the climates of the United States are so various that no one type can operate at maximum efficiency in all States, and some degree of designing for climate is essential. It is true that central heating, air conditioning and other "gadgets" can rectify almost any fault in design, but the architect's aim should be to foresee the climatic extremes and as far as possible minimise them without mechanical power. You don't do this by planting a Cape Cod house in a southern prairie.

One speaker from the building side advised his colleagues: "Don't throw out the climatologist too soon." Dr. Reichelderfer went further: "Don't throw him out at all, take him into your inmost councils." That is, in essence, the moral of this pioneer Conference.

C. E. P. BROOKS

The Shira Plateau of Kilimanjaro. By George Salt. *Geogr. J., London,* **117**, 1951, pp. 150–166.

The article by Dr. Salt in the June 1951 number of the *Geographical Journal* on the Shira plateau situated at 13,000 to 15,000 ft. above M.S.L. on the western side of Kilimanjaro includes sections on the climate of the plateau and on the glaciation of the Kibo summit of the mountain.

Dr. Salt visited the area in 1948 and found that the glaciers have receded very greatly since they were first studied at close quarters by Meyer and others in the 1890's. He estimates that if they continue to recede at the same rate there will be no ice-cap left by the end of another fifty years.

He notes that, by day, rising currents of warm air brought cloud up from the lower forest zone of the mountain and the plateau was usually walled with cloud on the south after midday. At night a cold down-current from the ice-cap above was observed. Frost occurred at night and rime formed on vegetation and ice on pools of water. The lowest temperature observed was $-2°$ C.

G. A. BULL

BOOKS RECEIVED

The geomagnetic field of the Netherlands reduced to 1945·0. By Dr. J. Veldkamp. Koninklijk Nederlands Meteorologisch Instituut. 13½ in. × 9½ in., pp. 30+7 charts, 17 in. × 13¼ in. Staatsdrukkerij-en Uitgeverijbedrijf 's-Gravenhage, 1951. Price: *fl.* 5.00.

Jaarboek B. Aardmagnetisme (Yearbook, B. Geomagnetism) 1947, Koninklijk Nederlands Meteorologisch Instituut. 13¼ in. × 9½ in., pp. iv+28, Staatsdrukkerij-en Uitgeverijbedrijf, 's-Gravenhage, 1950. Price: *fl.* 3.00.

Annual Report for 1941. Magnetic and meteorological results for 1948. Apia Observatory. 6 in. × 9½ in. pp. iv+170 and vi+154. New Zealand Department of Scientific and Industrial Research, Wellington, 1950.

NEWS IN BRIEF

Mr. W. Evetts, rainfall observer of Hampton, Tackley, Oxford, has for disposal a Stevenson screen and thermometers, also grass minimum and solar radiation thermometers. He will be pleased to hear from anyone willing to purchase these.

ROLL OF HONOUR OF METEOROLOGICAL OFFICE STAFF

It has been decided to prepare a Roll of Honour inscribed with the names of the staff of the Meteorological Office who lost their lives during the recent war. The dates for the duration of the war are those adopted by the Royal Air Force for the same purpose, September 3, 1939, to December 31, 1947. The following list of 63 names, which includes both members of H.M. Forces and civilians, has been prepared after exhaustive examination of documents and reference to individuals serving in the various theatres of war. Nevertheless, corrections may be necessary and there may be omissions. If any are noticed by readers, the Director would be glad to have the information.

Bankier, Lili Stefania	Palestine
Beuttell, Robert Gerard	Tiree
Blackburn, Edmund	At sea
Blagrove, Stanley	At sea
Brown, David Thomas	Chivenor
Brunning, Thomas Charles Joseph	Biggin Hill
Butfield, Edwin Henry Frederick	Biggin Hill
Campbell, Alastair William	Docking
Cartwright, Geoffrey	Tiree
Clark, Sydney John	Holland
Clifford, Norman John	At sea
Crichton-Miller, Campbell	Netheravon
Curd, Charles Daniel	Bircham Newton
Davidson, Jack	Tain
Edington, William Malcolm	North Africa
Fielding, Richard Allan	Iceland
Gange, Frank Cecil	India
Goatly, Percy Bernard	At sea
Gordon, John Macilrick Bryce	Brawdy
Groves, Louis Grimble	Brawdy
Halford, Glyn	Lichfield
Hedley-Smith, Edwin James	At sea
Henderson, William Milton	Malta
Hewitson, Donald Parr	Tiree
Hill, Joan Ellen	London
Holmes, Clive Douglas	India
Joseph, Peter Bernard	Turnberry
Legg, David Christian	Stradishall
Leigh-Clare, Howard Harry John	St. Davids
McCulloch, John Godbolt	East Africa
Martin, Richard Turner	Brawdy
Merridale, Reginald George	Holland
Montgomery, Robert Eckford	Bicester
Moore, Edward	Defford
Morse, Olive Mary	York
Mulligan, David Thomas	Brawdy
Nash, Robert Joseph	At sea
Portass, Sidney Leslie	At sea
Pressley, Dennis Alfred	Wick
Proud, Stanley	At sea
Pye, John Edward Bartle	St. Davids
Read, Harry	At sea
Rees, Meurig Thomas	Northwood
Rivers, Frederick Alan	At sea
Roberts, Norman Arthur	Biggin Hill
Rutherford, Richard	Snaith
Sharp, David Mountford	At sea
Short, Percy William Henry	At sea
Simmonds, Anthony Richard	Iceland
Smith, Peter Geoffrey	Tiree
Stevenson, Roy	Tiree
Tagg, Kenneth Thomas	Wattisham
Taylor, John Russell	Aden
Thom, Forbes Vivian	At sea
Thomas, Graham Nicholson	Aldergrove
Thompson, Albert Alexander	Aldergrove
Thomson, Keith Kilbourne	Tiree
Thorpe, Frederick Housden	Egypt
Trevitt, Kenneth	Langham
Watson, Collin George	At sea
Willis, Alfred James	Hornchurch
Wrighton, Richard Henry Roland	At sea
Vann, Arthur Hugh	North Africa

METEOROLOGICAL OFFICE NEWS

Agricultural Shows.—For the first time since 1935, an exhibit was staged by the Office at the Royal Highland Show, held this year at Aberdeen on June 19–22. Members of the staff from the Headquarters Branch dealing with agricultural meteorology and from the offices at Edinburgh and Dyce were on duty at the exhibit which formed part of the display organized by the North of Scotland College of Agriculture. The visitors, who came from all parts of Scotland, showed considerable interest in the instruments and models, especially in a working model of a wind-tunnel showing the different shelter-effects of a wall and a hedge. The wind-tunnel was also displayed at the Royal Cornwall Show at Newquay on July 11 and 12.

Visitors to Eskdalemuir Observatory.—On the 16th of May, 35 members of the Royal Meteorological Society (Scottish Branch) and their friends met at Eskdalemuir Observatory, and, under the guidance of the staff, visited in turn the huts for absolute magnetic measurements, the underground house containing the magnetographs, the rain and snow recorders, the radiation instruments and the atmospheric-potential recorder. Fine weather, the smooth efficiency of the arrangements, and the generosity of Mr. and Mrs. Crichton in providing tea for the party, all combined to make the visit a pleasant and memorable occasion.

Meteorological Association.—The summer meeting of the Meteorological Association was held at the Meteorological Office, Harrow, on Saturday, June 30. Some 55 members of the Association were received by the Director, who is also President of the Association, and Lady Johnson.

All branches at Harrow gave an exhibition of their work and tea was served in the canteen. Many war-time friendships were renewed in the course of the afternoon.

Much travelled.—A mysterious loss of correspondence addressed to Benbecula, Outer Hebrides, has been cleared up by its return from the New Hebrides in the south-west Pacific seven months after posting.

WEATHER OF JUNE 1951

Mean pressures were below 1020 mb. generally. They were between 1015 and 1020 mb. over western Europe except Scandinavia and mainly between 1010 and 1015 mb. over most of North America, the North Atlantic, Scandinavia and west Africa.

The area showing the greatest excess of pressure above normal was over the North Atlantic, north of 60° N., and Scandinavia, the excess varying from 2 to 5 mb. The largest deficit of pressure below normal occurred over the North Atlantic south of 60° N., the amount reaching 7 mb. in places.

Mean temperatures varied from 50° to 60° F. over most of Scandinavia and the British Isles, 60° to 70° F. over the rest of Europe, and 70° to 80° F. over the Mediterranean and north Africa. Departures from normal temperature were generally small; over west Europe they were about 1° to 2° F. above normal in places.

The weather in the British Isles was sunny generally and dry on the whole, though rainfall exceeded the average over part of Northern Ireland, much of east Scotland and in scattered places elsewhere.

During the first eight days a ridge of high pressure extended southward over the British Isles from an anticyclone in the north; the weather was unusually sunny, and dry apart from some slight rain and local thunder in the extreme south-west of England and Wales and at Guernsey on the 7th and 8th. Day temperatures were not particularly high except in the west and north-west (78° F. at Rothesay and Garvagh on the 4th, 81° F. at Glasgow, 79° F. at Glenbranter and 78° F. at Helensburgh and Paisley on the 5th and 78° F. at Ambleside on the 6th), while minimum temperatures were low at times (24° F. at Budden Ness on the 1st and Glenlivet on the 8th and 27° F. at Kielder Castle, Northumberland on the 1st and 2nd). On the 7th easterly winds of polar origin caused a considerable fall in temperature, by as much as 15° F. in the maximum at some places. On the 9th and 10th small depressions over southern Ireland and the southern North Sea were associated with rain in the south of Ireland and in England and Wales and local thunderstorms in England, but the weather continued dry and sunny on the whole in Northern Ireland and most of Scotland. From the 11th to the 14th Atlantic depressions moved north-east off our north-west seaboard, while secondary troughs of low pressure crossed the country. Rain fell in most areas on the 11th and 12th and in the north and west also on the 13th, while scattered rain or showers occurred on the 14th. Thunderstorms were rather widespread on the 12th. On the 16th and 17th a depression westward of Ireland moved east and turned north-east; rain fell generally except in east and south-east England and thunderstorms were recorded, chiefly in the west and north. Subsequently an anticyclone off our south-west coasts moved east-north-east to central Europe, while a trough associated with a depression west of Scotland moved across the country. Scattered showers, a few local thunderstorms and long sunny periods occurred on the 19th and rain, heavy locally in the north-west, on the 20th, but in the southern half of England the 20th was dry and sunny. Between the 21st and 26th a complex depression moved from Spain to Brittany, thence to the Low Countries and finally slowly northwards over the North Sea. Unsettled thundery weather prevailed for the most part and rainfall was heavy locally in east Scotland on the 25th (2·92 in. at Glenferness, Nairnshire and 2·88 in. at Keith, Banffshire). Thereafter a ridge of high pressure off our north-west coasts moved in over the British Isles, while a small depression off south-west Ireland moved east-south-east. Fair weather prevailed apart from rain in a few places in the south of England on the 28th. By the 30th the anticyclone was centred over England and the fair weather persisted except in the north-west and extreme north of Scotland, where weak troughs of low pressure caused some rain.

The general character of the weather is shown by the following provisional figures:—

	Air Temperature			Rainfall		Sunshine
	Highest	Lowest	Difference from average daily mean	Percentage of average	No. of days difference from average	Percentage of average
	°F.	°F.	°F.	%		%
England and Wales ...	78	27	+0·3	55	−3	116
Scotland	81	24	−0·6	85	−3	109
Northern Ireland ...	78	35	+0·3	101	−3	120

RAINFALL OF JUNE 1951

Great Britain and Northern Ireland

County	Station	In.	Per cent. of Av.	County	Station	In.
London	Camden Square ...	1·16	57	*Glam.*	Cardiff, Penylan ...	·67
Kent	Folkestone, Cherry Gdn.	1·65	83	*Pemb.*	Tenby	·99
,,	Edenbridge, Falconhurst	2·53	115	*Card.*	Aberystwyth	2·22
Sussex	Compton, Compton Ho.	3·00	120	*Radnor*	Tyrmynydd	1·23
,,	Worthing, Beach Ho. Pk.	1·88	107	*Mont.*	Lake Vyrnwy	1·96
Hants.	Ventnor Cemetery ...	1·37	72	*Mer.*	Blaenau Festiniog ...	3·87
,,	Bournemouth	·54	27	*Carn.*	Llandudno	1·14
,,	Sherborne St. John ...	·64	30	*Angl.*	Llanerchymedd ...	·87
Herts.	Royston, Therfield Rec.	1·26	56	*I. Man*	Douglas, Borough Cem.	·89
Bucks.	Slough, Upton	1·15	56	*Wigtown*	Port William, Monreith	1·91
Oxford	Oxford, Radcliffe ...	1·41	63	*Dumf.*	Dumfries, Crichton R.I.	1·35
N'hants.	Wellingboro' Swanspool	·99	47	,,	Eskdalemuir Obsy. ...	2·44
Essex	Shoeburyness	1·13	64	*Roxb.*	Kelso, Floors	1·55
,,	Dovercourt	1·18	67	*Peebles*	Stobo Castle	1·49
Suffolk	Lowestoft Sec. School ...	1·99	110	*Berwick*	Marchmont House ...	1·01
,,	Bury St. Ed., Westley H.	1·41	67	*E. Loth.*	North Berwick Res. ...	1·70
Norfolk	Sandringham Ho. Gdns.	1·71	79	*Midl'n.*	Edinburgh, Blackf'd. H.	1·41
Wilts.	Aldbourne	·97	42	*Lanark*	Hamilton W. W., T'nhill	2·32
Dorset	Creech Grange	·55	24	*Ayr*	Colmonell, Knockdolian	1·51
,,	Beaminster, East St. ...	·95	42	,,	Glen Afton, Ayr San. ...	1·51
Devon	Teignmouth, Den Gdns.	·82	43	*Bute*	Rothesay, Ardencraig ...	2·65
,,	Cullompton	1·17	55	*Argyll*	Morvern (Drimnin) ...	1·95
,,	Ilfracombe	·98	45	,,	Poltalloch	2·74
,,	Okehampton Uplands	1·92	69	,,	Inveraray Castle ...	2·79
Cornwall	Bude, School House ...	·51	25	,,	Islay, Eallabus	1·90
,,	Penzance, Morrab Gdns.	·59	27	,,	Tiree	1·71
,,	St. Austell	·81	31	*Kinross*	Loch Leven Sluice ...	2·63
,,	Scilly, Tresco Abbey ...	1·11	64	*Fife*	Leuchars Airfield ...	1·51
Glos.	Cirencester	1·30	54	*Perth*	Loch Dhu	4·14
Salop.	Church Stretton ...	·79	31	,,	Crieff, Strathearn Hyd.	2·38
,,	Shrewsbury	1·02	49	,,	Pitlochry, Fincastle ...	1·79
Worcs.	Malvern, Free Library	·64	28	*Angus*	Montrose, Sunnyside ...	1·88
Warwick	Birmingham, Edgbaston	1·13	49	*Aberd.*	Braemar	1·22
Leics.	Thornton Reservoir ...	1·18	55	,,	Dyce, Craibstone ...	2·11
Lincs.	Boston, Skirbeck ...	·91	50	,,	Fyvie Castle	2·89
,,	Skegness, Marine Gdns.	1·08	60	*Moray*	Gordon Castle	2·85
Notts.	Mansfield, Carr Bank ...	·91	40	*Nairn*	Nairn, Achareidh ...	1·67
Derby	Buxton, Terrace Slopes	2·49	77	*Inverness*	Loch Ness, Garthbeg ...	2·50
Ches.	Bidston Observatory ...	·61	28	,,	Glenquoich	4·18
Lancs.	Manchester, Whit. Park			,,	Fort William, Teviot ...	2·96
,,	Stonyhurst College ...	1·37	45	,,	Skye, Duntuilm ...	2·18
,,	Squires Gate	·59	28	*R. & C.*	Tain, Tarlogie House ...	1·32
Yorks.	Wakefield, Clarence Pk.	·71	33	,,	Inverbroom, Glackour...	1·60
,,	Hull, Pearson Park ...	1·32	64	,,	Applecross Gardens ...	3·41
,,	Felixkirk, Mt. St. John...	1·28	58	,,	Achnashellach	3·12
,,	York Museum	1·08	52	,,	Stornoway Airfield ...	2·34
,,	Scarborough	1·00	54	*Suth.*	Loch More, Achfary ...	4·90
,,	Middlesbrough... ...	1·58	84	*Caith.*	Wick Airfield	·83
,,	Baldersdale, Hury Res.	·86	36	*Shetland*	Lerwick Observatory ...	1·40
Norl'd.	Newcastle, Leazes Pk....	2·21	105	*Ferm.*	Crom Castle	3·20
,,	Bellingham, High Green	1·27	55	*Armagh*	Armagh Observatory ...	2·11
,,	Lilburn Tower Gdns. ...	1·15	56	*Down*	Seaforde	1·85
Cumb.	Geltsdale	1·79	66	*Antrim*	Aldergrove Airfield ...	2·70
,,	Keswick, High Hill ...	2·26	78	,,	Ballymena, Harryville...	3·29
,,	Ravenglass, The Grove	1·05	40	*L'derry*	Garvagh, Moneydig ...	3·44
Mon.	Abergavenny, Larchfield	·35	14	,,	Londonderry, Creggan	2·15
Glam.	Ystalyfera, Wern House	2·28	60	*Tyrone*	Omagh, Edenfel ...	2·78